SAMPLING THE UPPERMOST SURFACE OF AIRLESS BODIES. S. K. Noble[1] L. P. Keller[2] and R. Christoffersen[2], [1]NASA GSFC Mail Code 691 Greenbelt MD 20771, sarah.k.noble@nasa.gov, [2]NASA JSC Mail Code KR, Houston TX 77058.

Introduction: The uppermost surface of an airless body is a critical source of ground-truth information for the various remote sensing techniques that only penetrate nanometers to micrometers into the surface. Such samples will also be vital for understanding conditions at the surface and acquiring information about how the body interacts with its environment, including solar wind interaction, grain charging and levitation [1]. Sampling the uppermost surface while preserving its structure (e.g. porosity, grain-to-grain contacts) however, is a daunting task that has not been achieved on any sample return mission to date.

Apollo sampling: The importance of collecting a sample of the uppermost lunar surface was recognized during Apollo, and resulted in the design and deployment of the clam shell sampling devices (CSSDs) on Apollo 16 [2]. The two devices used Beta cloth (69003), similar to the outer layer of Apollo space suits, and velvet (69004) to collect the topmost ~100 and ~500 μm of the soil, respectively. Unfortunately, the CSSDs faced a couple of problems. First, sampling undisturbed soil is very difficult and the sampling protocol required the astronaut to "sneak up on a rock" and then reach behind it and sample in a largely blind maneuver on uneven ground. As a result, little material was collected, likely because of poor contact with the ground (Fig.1).

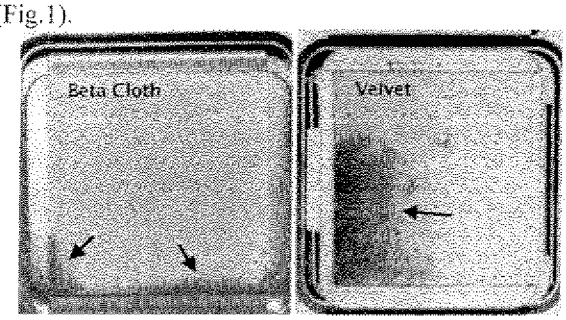

Figure 1. Apollo 16 Clam Shell Sampling Devices. Black arrows indicate the collected material.

Second, for the material that was collected there is evidence that various sampling biases were introduced. Some of the material, particularly the larger grains, fell off of the fabric in transit. Further, recent analysis has shown that at least the beta cloth fabric preferentially collects ultrafine grains (<2 μm) [3]. Similar tests have not yet been performed for the velvet, however, the velvet sample faces additional challenges because there are few techniques available to efficiently remove the particles from the velvet fibers. These sampling biases render the samples useless for assessing parameters such as the size distribution of the uppermost layer.

Potential samples: Sampling of the undisturbed uppermost surface of the lunar regolith should be integrated into operational plans for most, if not all, future robotic and human lunar surface missions. The goals should be to determine the degree to which the state of space weathering, and the composition, and/or particle size distribution differs from the bulk soil. Of particular interest would be lunar swirl sites. It has recently been postulated that transport of a very fine dust component may be responsible for swirl formation [4]. An examination of the uppermost surface would be the ideal way to test this hypothesis.

Previous asteroid missions have shown that both Eros and Itokowa have regions ("ponds") of finer material, indicating significant transport of fines. Samples from the uppermost surface of such ponded areas, as well as from more coarse-grained regions might shed light on the mechanisms controlling this process.

Future strategies: The solution to this sampling problem is challenging and will require new efforts to develop the proper collection mechanisms and protocols for both lunar and asteroidal sampling.

The ideal collection mechanism would uniformly collect the upper roughly 100 μms of undisturbed soil as well as a bulk soil from the top ~10 cm from the same location for comparison. Rather than fabric, a fly paper-like "sticky" substrate might be effective, though removing the sample could prove difficult, unless the substrate could be dissolved without compromising the sample. An alternate approach would be to impregnate the soil from above with a spray adhesive. This would be more logistically challenging, but would have the advantage of preserving grain orientations and any other delicate structures. Here again, the adhesive would have to be dissolvable so the grains could be extricated or strong and stable enough that the sample could be thin sectioned. Both methods would unfortunately introduce organics to the sample, which is problamatic for analysis of asteroidal soils.

Sampling on an asteroid is made more complicated by the very low gravity. Sample collection here is probably best accomplished robotically or through teleoporated methods prior to any human interaction. In order to ensure undisturbed soil, this sample should be collected before any other direct interaction with the body occurs.

References: [1] Mendell W. and S. Noble (2010) *LPSC XLI* Ab *#1348.* [2] Horz F. et al. (1972) *Apollo 16 Prelim Sci Report.* [3] Noble S. (2010) *LPSC XLI* Ab *#1505.* [4] Garrick-Bethell I. et al (2010) *LPSC XLI* Ab *#2675.*